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Appraisal of some granular insecticides against yellow-stem borer and Crop Water Productivity of Rice under two irrigation regimes

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Insect pests are serious threat to agricultural crops. Recurrent use of similar chemicals has resulted in many problems like resistance development in insects and hazardous effects on environments. The present research work was executed to probe out the comparative efficacy of some newer granular insecticidal formulations against yellow stem borer of rice, *Scirpophaga incertulus* (Walker). Recommended dose rates of the selected insecticides were used against the targeted insect pest. Results of incidence of S. *incertulus* larvae on paddy tillers showed that highest mean number population (22.40 larvae) were noted in experimental plots under flood irrigation compared with AWD irrigated plots (12.36 larvae). Data regarding dead-hearts revealed that maximum (8.5 dead-hearts /plot) were recorded in control followed by Cartap Hydrochloride (4.2 dead-hearts/plot) while lowest (2.21 dead-hearts/plot) by *S. incertulus* infestation were noted in chlorantraniliprol + Thiamethoxam plots under AWD irrigation. However, all the tested treatments were found superior over control. Results of white earheads showed that maximum (12.1 white earheads/plot) were recorded in case of control plot followed by Cartap Hydrochloride@ 22 kg/ha (4.16 white earheads/plot), Fipronil @20.0 kg/ha (3.78 white earheads/plot) whereas lowest (2.96 white earheads/plot) were recorded in chlorantraniliprol + Thiamethoxam treated plots. Crop water productivity of paddy plots under AWD irrigation was 0.29 kg/m^3 comparatively greater than plots under flood irrigation i.e., 0.12 kg/m^3. Use of new granular formulation of insecticide together with improved irrigation can be helpful for Integrated Management of yell stem borer of rice.

Keywords: Frequent, harmful, highest, insect pest infestation, improved irrigation.

INTRODUCTION

Water shortage is turning to be a huge problem worldwide. Furthermore, over 70% of the world's fresh water is being used in agriculture and the requirement is projected to rise to encounter upcoming food security (Kang *et al*., 2021). Water scarcity is resulting in desiccating of water sources like rivers, lakes, periodic streams and dropping irrigated rice production. Surface and underground water resources are shrinking, which is posing a threat to the future of rice production (Carrijo and Lundy, 2017). The current challenge for paddy rice cultivators is to increase the water productivity by growing rice with less water, which is possible (Qun *et al*., 2017). The promotion and adoption of effective water -use saving techniques for rice production to reduce irrigation water requirement in the agricultural sector without affecting the yields (Ishfaq *et al*., 2020), with climate change being inevitable, is necessary. Alternate wetting and drying (AWD) irrigation is panacea for water scarcity glitches (Pourgholam-Amiji *et al*., 2020). Worldwide, AWD is known as a climate-smart water-saving practice being applied in several Asian countries like Bangladesh, Vietnam, India and China (Yao *et*

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al., 2012; Ishfaq *et al*., 2020). Many researchers practiced this technique for irrigation water saving as compared to flood irrigation (Pascual *et al*., 2017; Ishfaq *et al*., 2020; Mboyerwa *et al*., 2021). Farmers are being motivated to use the "safe AWD" practice in non-reproductive growth phase and later on at the grain-filling phase (Carrijo *et al*., 2017; Howell *et al*., 2015).

Rice (*Oryza sativa* L.) among the most staple food crops; it is judgmentally significant for food security to 1/2 of the world's population, where rice accounts for around 80% of food consumption (Djaman *et al*., 2020). It has been grown in greater than 146.5 million hectares of the world's cropping soil (Lampayan *et al*., 2015), though the yield of rice is meaningfully reduced by water shortage problems. Rice is a significant cereal crop and it offers food security to the huge population of world (Pourgholam-Amiji *et al*., 2020). It is the 3rd main crop grown in Pakistan afterward cotton and wheat. In Pakistan, in year 2020-21, there was 3.335 million hectares area under rice crop with 8.419 million-ton yield. Share of rice in countrywide GDP is 0.7% and for value addition in Agriculture is 3.5%, so it is among the highly desired crops of Pakistan(Anonymous, 2021). Thin rice grains genotypes of Pakistan, predominantly fine rice varieties are highly well-known everywhere in the world due to their particular fragrance. Owing to this exceptionality, rice is a shipped goods of Pakistan and has attained a position of 2nd highly significant cereal crop. Basmati 515 is a result of three way cross of F_1 (Basmati 320 x 10486) with 50021 during 1995-96 (Akhtar *et al*., 2014).

The yield of rice is decreasing owing to numerous abiotic and biotic (living) issues. Yarasi *et al*. (2008) described that around 52 % of rice cultivation is reduced owing to injury instigated by living factors. Attack of insect pest is too a significant aspect amongst additional constraints for less average yield per unit area. Insects are the main living factor that can result in 21% decrease in rice crop produce in rice-wheat cropping patterns of Pakistan. Among these insect pests, stem borers and plant hoppers of rice crop are of prime importance (Yadav *et al*., 2019). Among the insect pests, stem borers and plant hoppers of rice crop are the most notorious pests (Shahbaz *et al*., 2021). Among the stem borers, yellow-stem borer are of prime importance. Larvae of yellow-stem borers (YSB) mainly bore into main stalk by generating dead hearts and white heads at non-reproductive and reproductive phases of rice crop development, correspondingly (Kakshapati *et al*., 2022). It turns into necessary to spray the rice filed with a suitable entomocidal chemical, when population of the insect pest ranges to its economic threshold level. As the harm at this stage is a stern setback to crop produce and can merely be reduced through use of suitable granular insecticide (Renuka *et al*., 2017). Farmers mostly depend on insecticides for the control of insects in paddy and nearly half of the applied entomocidal chemicals are focused against YSB (Reddy *et al*., 2012). Though, frequent use of similar insecticides also resulted in adverse impacts comprising of resurgence of the pest, ecological pollution, development of resistance in insects and buildup of insecticide remains in commodities. To combat such issues, novel formulations of entomocidal chemicals are being made available in marketplace on yearly basis that could fulfill entire requirements in a comparatively effective way, particularly the granular pesticides (Ali *et al*., 2022). At the booting phase of rice crop, plant populations are usually maximum and majority of the farmers are used to of foliar spray that does not provide necessary outcomes owing to presence of pest at stem base. Such activities decrease the crop yield due to reduced insect control together with harmful impacts on human beings. Therefore, availability of new formulations of insecticides and sensible application of the insecticides are extremely compulsory to overcome such problematic situation (Fenibo *et al*., 2022). A comprehensive analysis of past research works has revealed that numerous entomocidal chemicals in diverse formulations particularly chlorantraniliprol comprising granulated insecticides are extremely operative against borers of paddy stalks (Sahu *et al*., 2020). Furthermore, virteko (thiamethoxam 0.4% + chlorantraniliprole 0.2%) too shown to be a fruitful choice for controlling rice plant hoppers, leaf folder and stem borers (Baskaran *et al*., 2013). Likewise, Mishra *et al*. (2012) described the fipronil as an effectual entomocidal chemical for the control of stem borers. Hence, applications of innovative formulations with systemic mode of actions possess a significant role in controlling all such insect pests and can too cope up the insecticides resistance issues. Furthermore, granulated insecticides are too well-familiar for their lesser poisonousness against biocontrol agents (Sanchez-verdejo *et al*., 2008) therefore can meaningfully upsurge the rice crop yield (Khan *et al*., 2010). The current research was conducted to evaluate the insecticidal potentials of some newly selected granular insecticides against rice plant hoppers and stem borer as well as provides technical information on the use of AWD practice.

MATERIALS AND METHODS

***Location Features and experimental design*:** The research trial was executed at Water Management Research Farm, Renala Khurd, Okara during 2021 which has a longitude and latitude of 30.8782° N, 73.5954° E, correspondingly and is 67 m above sea level. The experiment was laid out in a split-block design having three replications with a net plot size of 326 m^2 for data collection. The field was thoroughly prepared by giving one deep ploughing trailed by 2 with the help of cultivator comprising planking. The seed of Basmati-515 variety was sown in nursery at 7 days interval. Two seedings/hole was transplanted by following the similar timetable. R×R and P×P distance was maintained at 22.5 cm each. Granular insecticides were applied for the control of

stem borer and plant hoppers. The selected insecticides were used two times with suggested dose. The 1st use of the insecticides was done 55 days afterward transplanting the nursery and the 2nd time application was executed 7 days afterward start of the panicle in stagnant water situations to attain constant application of the insecticides. Furthermore, the research plots were disjointed by wide edges (2 m wide and 0.26 m high) to evade transport of insecticides and moisture content to neighboring experimental plots. Entire phosphorus (Diamonium Phosphate; DAP) was applied in the field prior to nursery transplanting. Potassium (Sulfate of Potash) and nitrogen (Urea) were applied in two equivalent quantities. The 1st half dose of Sulfate of Potash was used earlier to transplanting together with DAP and 2nd application was applied at booting stage of rice crop. While, the paddy filed was fertigated at identical doses after two intervals of 25 days afterward transferring the paddy nursery to the experimental filed. *R×R=row-row distance, P×P=plant-plant distance.

Table 1. Treatments description.

Treatments	Name of insecticide	Dose rate/acre
T_1	Fipronil	@ 10.0 kg ha^{-1}
T_2	Cartap Hydrochloride	@ 22 kg ha^{-1}
T_3	Fipronil + Cartap hydrochloride	@ 11.0 kg ha^{-1}
T_4	Chlorantraniliprol + thiamethoxam	@ 20.0 kg ha^{-1}
To	Control	

Water Regimes: The continuous flooding irrigation (CF) as a control treatment was used in the entire rice-growth period, in which irrigation was applied when field water reduced to a zero level on the superficial layer of soil. The measured irrigation was applied to the research plots at each time. Alternate wetting and drying (AWD) circumstances defined as AWD15 correspond to the crop irrigation period when level of water in the AWD pipe touches to 15 cm in soil depth afterward the vanishing of soil surface water. AWD situation cascades under the eco-friendly tactic suggested by the International Rice Research Institute (IRRI) not to result in yield drop (Richards and Sander, 2014).

***Field Conditions and Measurements*:** Rice variety, Basmati-515, was directly seeded on 25 June, 2021 and standing water treatment was sustained for 21 days through calculated amount of water through cut-throat flume for suppression of weeds. All the irrigations throughout the crop period were applied through water flow measuring flume called cut-throat flume. Water application in all regimes was stopped one week prior to harvesting.

***Insect pests monitoring*:** A consistent field monitoring was conducted for spotting the attack of stem borer and plant. For stem borer, dead hearts at non-reproductive period while white heads were recorded at reproductive phase from every experimental unit. For calculation of yellow stem borer larvae, numbers of larvae/plant were noted from 10 arbitrarily designated paddy hills at three altered experimental sites from every experimental plot during the study period. Population of stem borers attack /plant was calculated by means of equations as given below and percent decrease over control was too computed.

$$\text{Stem Borer infestation (\%)} = \frac{\text{Number of dead hearts/white heads}}{\text{Total number of tillers}} \text{x}100$$

***Water productivity*:** was calculated by dividing grain yield by total amount of water applied as given below:

$$\text{Water Productivity (Kg/m}^3\text{)} = \frac{\text{Grain Yield (Kg/ha)}}{\text{Amount of water applied (m}^3\text{ /ha)}} \times 100$$

For approximation of rice crop produce, every plot of the research trial was harvested, threshed and weighed up distinctly and later on the grain produce was transformed to kg/ha.

***Data analysis*:** The collected numeral information were examined through Analysis of Variance (ANOVA) techniques and LSD test was used to evaluate significant different among the treatments at 5% probability level.

RESULTS

Results revealed relative incidence of *Scirpophaga incertulus* larvae on paddy tillers was significantly different ($p<0.05$) in plots under two types of irrigation. Maximum mean number population (22.40 larvae/six plots) was noted in experimental plots under flood irrigation compared with AWD irrigated plots (12.36 larvae/six plots) (Figure 1).

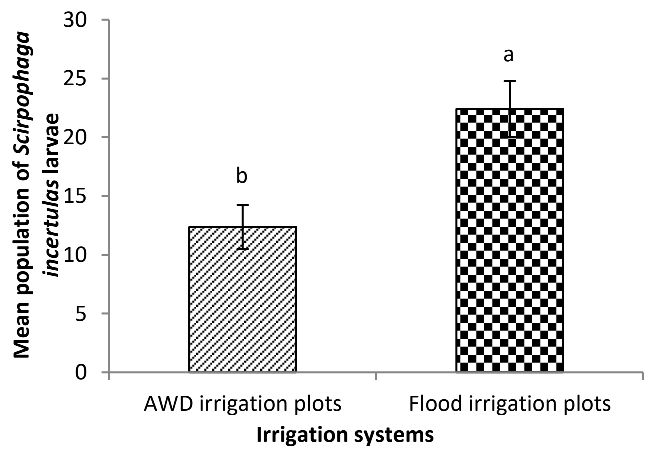

Figure 1. Mean incidence of *Scirpophaga incertulus* larvae in AWD and flood irrigated plots.

Results regarding dead-hearts under AWD irrigation plots revealed that maximum (8.5 dead-hearts /plot) were recorded in control followed by Cartap Hydrochloride (4.2 dead-hearts/plot) while lowest (2.21 dead-hearts/plot) by *S.*

incertulus infestation were noted in chlorantraniliprol + Thiamethoxam treated plots. However, all the tested treatments were found superior over control. Results of white earheads showed that maximum (12.1 white earheads /plot) were recorded in case of control plot followed by Cartap Hydrochloride@ 22 kg/ha (4.16 white earheads), Fipronil @20.0 kg/ha (3.78 white earheads /plot) whereas lowest (2.96 white earheads /plot) were recorded in chlorantraniliprol + Thiamethoxam treated plots (Table 2).

Table 2. Mean percent dead-hearts and white-heads produced by infestation of *Scirpophaga incertulas* in AWD irrigation plots during Kharif season-2021.

Treatments	Dead Hearts (DH) ± S.E	White-heads (WH) ± S.E
Cartap Hydrochloride	4.2±3.23b	4.16±3.21b
Fipronil	3.46±2.89c	3.78±2.52bc
Cartap+Fipronil	2.81±2.35d	3.12±2.67c
Chlorantraniliprol+Thiamethoxam	2.21±2.96e	2.96±2.56d
Control	8.5±3.35a	12.1±3.18a

*Means not sharing different letters within a column differ significantly from each other at p ≤0.05.

Outcomes showed that highest reduction (82.60%) of *S. scirpophaga* infestation over control was recorded in AWD irrigated plots treated with Chlorantraniliprol+Thiamethoxam followed by Cartap+Fipronil (72%), Fipronil (65.30%) while relative low reduction (41.5%) was noted in case of Cartap Hydrochloride but was superior over control plot (19.4%) infestation (Fig. 2).

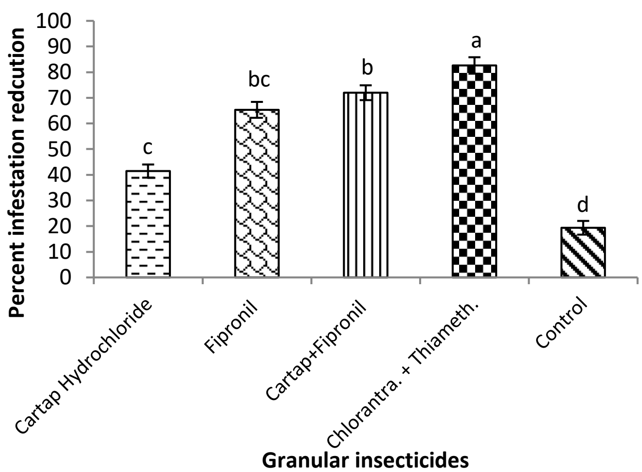

Figure 2. Reduction (%) in *Scirpophaga incertulas* infestation through application of dissimilar insecticides in AWD irrigation plots during Kharif season-2021.

Results displayed that maximum reduction (63.80%) of *S. scirpophaga* infestation over control was recorded in plots treated with Chlorantraniliprol+Thiamethoxam shadowed by Cartap+Fipronil (48.90%), Fipronil (40.21%) whereas comparatively less reduction (21.19%) was recorded in case of Cartap Hydrochloride however was superior over control plot (7.20%) infestation (Fig. 3).

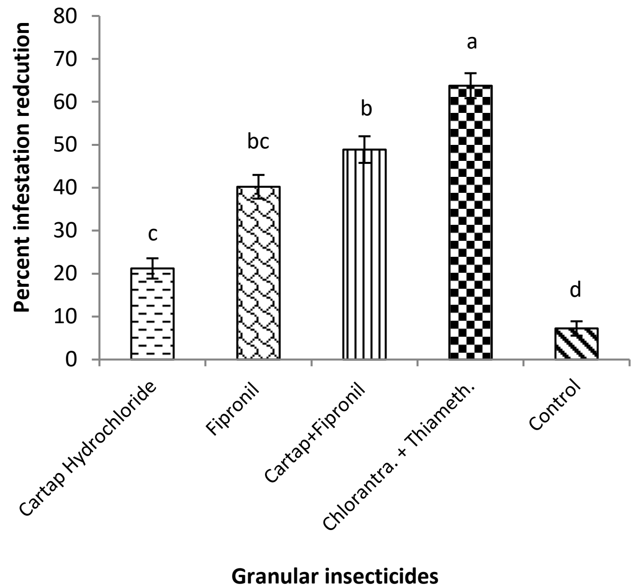

Figure 3. Reduction (%) in *Scirpophaga incertulas* infestation through application of dissimilar insecticides in Flood irrigation plots during Kharif-2021.

Results regarding dead-hearts under flood irrigation plots shown that highest (18.89/plot) were noted in case of control plot followed by Cartap Hydrochloride (14.67 dead-hearts) whereas lowermost (2.21 dead-hearts/plot) by *S. incertulus* infestation were noted in chlorantraniliprol+Thiamethoxam treated plots. However, all the tested treatments were found superior over control. Results of white earheads showed that maximum (12.1 dead-hearts /plot) were recorded in case of control plot followed by Cartap Hydrochloride@ 22 kg/ha (4.16 white earheads), Fipronil @20.0 kg/ha (3.78 white earheads /plot) whereas lowest (5.32 white earheads /plot) were recorded in chlorantraniliprol + Thiamethoxam treated plots (Table 3).

Results of crop yield showed that yield in rice plots under AWD greater (13.1 maunds) compared with flood irrigation (7.2 maunds). Moreover, crop water productivity with AWD practice was superior (0.29 kg/m^3 over control (0.12 kg/m^3) (Table 4).

Table 3. Mean percent dead-hearts and white-heads produced by infestation of *Scirpophaga incertulas*

in Flood irrigation plots during Kharif season-2021.

Treatments	Dead hearts (DH) ± S.E	White earheads (WH) ± S.E
Cartap Hydrochloride	14.67±3.23b	15.36±3.18b
Fipronil	12.10±2.89c	12.43±2.71bc
Cartap + Fipronil	8.19±2.92d	9.56±2.87c
Chlorantraniliprol + Thiamethoxam	5.32±2.90e	4.58±2.56d
Control	18.89±3.10a	19.35±3.14a

*Means not sharing different letters within a column differ significantly from each other at $p \leq 0.05$.

Table 4. Comparison of Water Productivity of rice crop under AWD and Flood irrigation system.

Treatments	Results/Outcomes		
	Actual Water applied (mm)	Yield (mounds/half acre^{-1})	Water Productivity (kg/m^3)
AWD Irrigation	962	13.1	0.28
Flood irrigation	1248	7.2	0.12

Note: Rainfall throughout the study period was 278 mm.

DISCUSSION

Our results were corroborated by the findings of Sarao and Kaur (2014) whom described that novel formulated entomocidal chemical, chlorantraniliprol was highly operative in controlling stem borer. The results of current research work are corroborated with research work of Naik and Semi (2017) whom noted that chlorantraniliprol was superior for the management of insect pests of paddy crop. Singh *et al*. (2015) too described that fipronil and chlorantraniliprol were relatively superior in reducing infestation of *S. incertulus* in paddy crop. Use of granulated insecticides for the control yellow stem borer and other rice stem borers was expounded by numerous investigators such as Satyanarayana observed that fipronil was operative in controlling rice stalk borers. One more captivating surveillance with respect to useful insect was too showed that application of granular insecticides in stagnant water did not reduce the members of useful insects. Results were supported by Shahbaz *et al*. (2021) assessed the efficacy of few granular insecticides against stem borers and found chlorantraniliprol+Thiamethoxam as the most effective one; same was noted in the current research work. The results of increased reduction in *S. incertulus* infestation were in line with Sahu *et al*. (2020) whom evaluated the numerous granular insecticides formulations against stem borers of paddy crop and found chlorantraniliprol as the extremely operative against stem borers and The results were supported by Shahbaz *et al*. (2021) whom tested different granular insecticides against stem borers of paddy crop and observed relatively low infestation in chlorantraniliprol+Thiamethoxam treated plots as was noted in our research work. Singh *et al*. (2015) too described that fipronil and chlorantraniliprol were relatively superior in reducing infestation of rice stem borers in rice crop. Our results were corroborated with Pallavi *et al*. (2018) whom described the chlorantraniliprole 0.4% GR and flubendiamide 480% SC highly operative for decreasing *S. incertulus* infestation as compared to fipronil 0.3%, the same was noted in our research work. The current outcomes are reinforced by the research work of Nirmalkar *et al*. (2015) and Omprakash *et al*. (2017) whom noted that chlorantraniliprole 0.4% GR was the highly operative granular insecticide against *S. incertulus* owing to new mode of action than the other granular insecticides. Chormule *et al*. (2014) too found that chlorantraniliprole 0.4% GR was the most effective compared to all the other assessed insecticides with abridged stem borer infestation. Alike findings were described by Tondon and Shrivastav (2016) whom noted that chlorantranilprole 20% SC significantly reduced the white earhead and dead hearts in paddy crop as compared to other granular insecticides. Results of rice water productivity were supported by Ishfaq *et al*. (2020) whom executed research work on comparative water productivity of rice under AWD and continuous flood irrigation regimes, noted relatively greater water productivity of rice plots under AWD irrigation compared with flood irrigation.

***Conclusion*:** Novel granular insecticides can be effective for the control rice stem borers. In this research work, Chlorantraniliprol+Thiamethoxam and Cartap+Fipronil were comparatively more effective than other tested granular insecticides against *S. incertulus*. Individual application of Cartap and Fipronil was less effective than the combined application for the control of *S. incertulus*. Rice stem borers are serious threat to paddy production, hence there is dire need of application of novel granular insecticides to cop up the insect infestation.

***Authors' contributions*:** Rehman H and Qurban A: Conceived the idea, planned the study, and wrote the manuscript; Mohsin M and Akram, M: Reviewing and editing; Bilal M, SHK Naqvi and Mujahid A: Assisted in field work; Usman M and Ahsan H: Assisted in design layout and proofreading

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***Availability of data and material*:** The data will be available on realistic demand.

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